

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

(Feet)

CODE 606

DEFINITION

A conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.

PURPOSE

The purpose of subsurface drainage is to:

1. Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:
 - a. regulating water table and ground water flows,
 - b. Intercepting and preventing water movement into a wet area,
 - c. Relieving artesian pressures,
 - d. Removing surface runoff,
 - e. Leaching of saline and sodic soils,
 - f. Serving as an outlet for other subsurface drains, and
 - g. Regulating sub-irrigated areas or waste disposal areas.
2. Collect ground water for beneficial uses.
3. Remove water from heavy use areas, such as around buildings, roads, and play areas; and accomplish other physical improvements related to water removal.
4. Regulate water to control health hazards caused by pests such as flukes, flies, or mosquitoes.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to areas having a high water table where the benefits of lowering the water table or controlling ground water or surface runoff justify installing such a system.

This standard applies to areas suitable for the intended use after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system.

In areas where an outlet is available, either by gravity flow or by pumping, the outlet shall be adequate for the quantity and quality of effluent to be discharged.

CRITERIA

The design and installation shall be based on adequate surveys and investigations.

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Capacity

One or more of the following shall determine the required capacity:

1. Application of a locally tried and proven drainage coefficient to the acreage drained, including added capacity required to dispose of surface water entering through inlets.
2. Yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.
3. Comparison of the site with other similar sites where subsurface drain yields have been measured.
4. Measurement of the rate of subsurface flow at the site during a period of adverse weather and ground water conditions.
5. Application of Darcy's law to lateral or artesian subsurface flow.
6. Estimates of lateral or artesian subsurface flow.

The required capacity of the drain can be determined from charts and tables in Chapter 14 of the Engineering Field Manual for Conservation Practices. Where the land to be drained has adequate surface drainage, either natural or artificial, the following coefficients are recommended.

Soil	Inches to be Removed in 24 Hours	
	Field Crops	Truck Crops
Mineral	3/8 to 1/2	1/2 to 3/4
Organic	1/2 to 3/4	3/4 to 1-1/2

Where it is necessary to admit surface water to the subsurface drain system through surface inlets:

Soil	Inches to be Removed in 24 Hours			
	Field Crops		Truck Crops	
	Blind/Inlets	Open Inlets	Blind/Inlets	Open Inlets
Mineral	1/2 to 3/4	1/2 to 1	3/4 to 1	1 to 1-1/2
Organic	3/4 to 1	3/4 to 1-1/2	1 to 2	2 to 4

Where high value truck crops might be damaged by water standing on them from 2 to 4 hours during hot weather, a higher coefficient than those given above and/or closer drain spacing shall be necessary to hold crop damage to a minimum.

Size

The size of subsurface drains shall be computed by applying Manning's formula. The size shall be based on the required capacity and computed by using one of the following assumptions:

1. The hydraulic gradeline is parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.
2. The conduit flowing partly full where a steep grade or other conditions require excess capacity.
3. Conduit flowing under pressure with hydraulic gradeline set by site conditions on a grade that differs from that of the subsurface drain. This procedure shall be used only if surface water inlets or nearness of the conduit to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

The outlet pipe is part of the hydraulic system, and its grade and roughness characteristic ("n" value) must be considered in determining the required size of the outlet pipe.

All subsurface drains shall have a nominal diameter that equals or exceeds 3 inches.

Depth, Spacing, and Location

The depth, spacing, and location of the subsurface drain shall be based on site conditions, including soils, topography, ground water conditions, crops, land use, outlets, and saline or sodic conditions. The recommendations in the Ohio Drainage Guide will be used unless special field studies are made to determine spacing requirements.

The minimum depth of cover over subsurface drains in mineral soils shall be 2 feet. This minimum depth shall apply to normal field levels and may exclude sections of line near the outlet sections laid through minor depressions where the conduit is not subject to damage by frost action or equipment travel.

The minimum depth of cover in organic soils shall be 2.5 feet for normal field levels, as defined above, after initial subsidence. Structural measures shall be installed if it is feasible to control the water table level in organic soils within the optimum range of depths.

The maximum depth of cover for standard duty corrugated plastic tubing shall be 10 feet for trench widths of 2 feet or less (measured at tubing and to 1 foot above top of tubing). Heavy-duty tubing shall be specified for depths greater than 10 feet, trench widths more than 2 feet, or in rocky soils.

For computation of maximum allowable loads on subsurface drains, use the trench and bedding conditions specified and the crushing strength of the kind and class of drain. The design load on the conduit shall be based on a combination of equipment loads and trench loads. Equipment loads are based on the maximum expected wheel loads for the equipment to be used, the minimum height of cover over the conduit, and the trench width. Equipment loads on the conduit may be neglected when depth of cover exceeds 6 feet. Trench loads are based on the type of backfill over the conduit, the width of the trench, and the unit weight of the backfill material. A safety factor of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Minimum Velocity and Grade

In areas where sedimentation is not a hazard, the minimum grades shall be based on site conditions and a velocity of not less than 0.5 feet per second (ft/s). If a hazard exists, a velocity of not less than 1.4 ft/s shall be used to establish the minimum grades if site conditions permit. Otherwise, provisions shall be made for preventing sedimentation by use of filters or by collecting and periodically removing sediment from installed traps, or by periodically cleaning the lines with high-pressure jetting systems or cleaning solutions.

Maximum Velocity without Protection

Excessive flow velocity in the drain may induce piping of soil material into the drain line.

<u>Maximum velocities by soil texture:</u>	
<u>Soil Texture</u>	<u>Velocity ft/s</u>
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silt clay loam	6.0
Clay and clay loam	7.0
Course sand or gravel	9.0

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Maximum Grade and Protection

On sites where topographic conditions require that drain lines be placed on steep grades and design velocities will be greater than indicated under “Maximum velocity without protection,” special measures shall be used to protect the conduit or surrounding soil. These measures shall be specified for each job according to the particular conditions of the job site.

The protective measure shall include one or more of the following:

1. Enclose continuous perforated pipe or tubing with fabric-type filter material or properly graded sand and gravel.
2. Use non-perforated continuous tubing, a watertight pipe, or seal joints.
3. Place the conduit in a sand and gravel envelope or blinding with the least erodible soil available.
4. Select rigid butt end pipe or tile with straight, smooth sections and square ends to obtain tight fitting joints.
5. Wrap open joints of the pipe or tile with tar impregnated paper, burlap, or special fabric-type filter material.
6. Install open-air risers for air release or entry.

Iron Ochre Control

If drains are to be installed in sites where iron ochre and manganese dioxide problems are likely to occur, provisions should be made to provide access for cleaning the lines. Each drain line should outlet directly into an open ditch and/or should have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions should be installed in such a way that the drains can be cleaned in an upstream or rising grade direction. If possible, drains in ochre-prone areas should be installed during the dry season when the water table is low and the iron and manganese dioxide is in its insoluble form.

Where possible, in areas where the potential for such problems is high, protection against their development can be provided by designing an outlet facility to ensure permanent submergence of the drain line.

Protection against Root Clogging

Problems may occur where it is necessary to place drains in close proximity to perennial vegetation. Roots of water-loving trees, such as willow, cottonwood, elm, and soft maple, or some shrubs and grasses growing near subsurface drains may enter and obstruct the flow.

Where possible, use non-perforated tubing or closed joints through the root zone area. Where this is not possible, water-loving trees should be removed from a distance of at least 100 feet on each side of the drain. A distance of 50 feet should be maintained from other species of trees except for fruit trees. Orchards can often be drained by drain lines located close to the fruit trees.

Where crops and grasses may cause trouble on drain lines, facilities may be installed to provide a means for submerging the line to terminate the root growth as desired or to maintain a water table above the drainlines to prevent growth into the system.

Materials

Subsurface drains include conduits of plastic, clay, concrete, bituminized fiber, metal, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements for the site. All conduits shall meet or exceed the minimum requirements of the appropriate specifications published by the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), and the American Water Works Association (AWWA).

Foundation

If soft or yielding foundations are encountered, the lines shall be stabilized and protected from settlement by adding gravel or other suitable materials to the trench, by placing the conduit on a treated plank that will not readily decompose or on other rigid supports, or by using long sections or perforated or watertight pipe having adequate strength to ensure satisfactory subsurface drain performance. The use of a flat treated plank is not recommended for corrugated plastic tubing.

Filters and Filter Material

Filters will be used around conduits, as needed, to prevent movement of the surrounding soil material into the conduit. The need for a filter will be determined by the characteristics of the surrounding soil material, site conditions, and the velocity of flow in the conduit. A suitable filter should be specified if:

1. Local experience indicated a need.
2. Soil materials surrounding the conduit are dispersed clays, silts with a plasticity index less than 7, or fine sands with a plasticity index less than 7.
3. Deep soil cracking is expected, or
4. The method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation shall be designed in accordance with National Engineering Handbook (NEH) Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 inches of filter material except that the top of the conduit and side filter material may be covered by a sheet of plastic or similar impervious material to reduce the quantity of filter material required. In all cases the resulting flow pattern through filter material shall be a minimum of 3 inches.

Artificial fabric or mat-type filter materials may be used, provided that the effective opening size, strength, durability, and permeability are adequate to prevent soil movement into the drain throughout the expected life of the system.

Envelopes and Envelope Material

Envelopes shall be used around subsurface drains if they are needed for proper bedding of the conduit or to improve the characteristics of flow of ground water into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they must not contain materials that will cause an accumulation of sediment in the conduit or that will render the envelope unsuitable for bedding of the conduit.

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Envelope materials shall consist of sand-gravel, organic, or similar material. Sand-gravel envelope materials shall all pass a 1.5-inch sieve; not more than 30 percent shall pass a No. 50 sieve; and not more than 5 percent shall pass the No. 200 sieve. ASTM-C-33 fine aggregate for concrete has been satisfactorily used and is readily available.

Where organic or other compressible materials are used, they shall be used only around a rigid wall conduit and above the centerline of flexible tubing. All organic or other compressible material shall be of a type that will not readily decompose.

Placement and Bedding

The conduit should not be placed on exposed rock or stones more than 1.5 inches in diameter for 6 inch or larger tile and stones no more than $\frac{3}{4}$ inch diameter for tile less than 6 inches. Where such conditions are present the trench must be over-excavated, a minimum of 6 inches and refilled to grade with a suitable bedding material.

The conduit must be placed on a firm foundation to ensure proper alignment. Prevent runoff and surface water from entering the trench.

If installation will be below a water table or where unstable soils are present, special equipment, installation procedures, or bedding materials may be needed. These special requirements may also be necessary to prevent soil movement into the drain or plugging of the envelope if installation will be made in such materials as quicksand or a silt slurry.

For trench installations of corrugated plastic tubing 8 inches or less in diameter, one of the following bedding methods will be specified:

1. A shaped groove or 90° V-notch in the bottom of the trench for tubing support and alignment.
2. A sand-gravel envelope, at least 3 inches thick, to provide support.
3. Compacted soil bedding material beside and to 3 inches above the tubing.

For trench installations of corrugated plastic tubing larger than 8 inches, the same bedding requirements will be met except that a semi-circular or trapezoidal groove shaped to fit the conduit will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements will be met except that a groove or notch is not required.

All trench installations should be made when the soil profile is in its driest possible condition in order to minimize problems of trench stability, conduit alignment, and soil movement into the drain.

For trench installations where a sand-gravel or compacted bedding is not specified, the conduit should be blinded with selected material containing no hard objects larger than 1.5 inches in diameter. Blinding should be carried to a minimum of 3 inches above the conduit.

Where the conduit will be bedded with fine-grained friable soil or a sand and gravel mixture, the minimum trench width will be at least 0.5 ft. greater than the outside diameter of the conduit. When the conduit is installed in conditions where cloddy material will likely be used for bedding, the trench width will be at least 1.0 ft. greater than the outside diameter of the conduit. In all cases the conduit will be laid in the center of the trench.

All installations shall meet the minimum requirements of the appropriate ASTM specification.

Auxiliary Structures and Protection

Structures installed in drain lines must not unduly impede the flow of water in the system. Their capacity must be no less than that of the line or lines feeding into or through them. The use of internal couplers for corrugated plastic tubing will be allowed.

If the drain system is to carry surface water flow, the capacity of the surface water inlet shall not be greater than the maximum design flow in the drain line or lines. Covers or trash racks should be used to ensure that no foreign materials are allowed in the drain lines.

The capacity of a relief well system will be based on the flow from the aquifer, the well spacing, and other site conditions and will be adequate to lower the artesian waterhead to the desired level.

The size of relief wells is generally based on the available materials rather than on hydraulic considerations. Such wells will not be less than 4 inches in diameter.

Junction boxes, manholes, catch basins, and sand traps must be accessible for maintenance. A clear opening of not less than 2 feet will be provided in either circular or rectangular structures.

The drain system must be protected against velocities exceeding those provided under “**Maximum velocity without protection**” and against turbulence created near outlets, surface inlets, or similar structures. Continuous or closed-joint pipe must be used in drain lines adjoining the structure where excessive velocities will occur.

Junction boxes shall be installed where three or more lines join or if two lines join at different elevations. In some locations it may be desirable to bury junction boxes. A solid cover should be used, and the junction box should have a minimum of 1.5 feet of soil cover.

If not connected to a structure, the upper end of each subsurface drain line will be capped with a tight-fitting external cap of the same material as the conduit or other durable materials.

Outlets

The outlet must be protected against erosion and undermining of the conduit, entry of tree roots, damaging periods of submergence, and entry of rodents or other animals into the subsurface drain. A continuous section of rigid pipe without open joints or perforations will be used at the outlet end of the line and must discharge above the normal elevation of low flow in the outlet ditch. Standard corrugated plastic tubing is not suitable for the outlet section. Minimize the visual impact of projecting outlets.

Continuously submerged outlets will be permitted for water table control systems if planned and designed according to the standard for Drainage Water Management (554).

The outlet pipe and its installation will conform to the following requirements:

1. If burning vegetation on the outlet ditch bank is likely to create a fire hazard; the material from which the outlet pipe is fabricated must be fire resistant. If the likelihood is great, the outlet pipe must be fireproof.
2. Two-thirds of the pipe will be buried in the ditch bank, and the cantilever section must extend to the toe of the ditch side slope or the side slope protected from erosion. The minimum length of the pipe will normally be 8 feet. Under certain conditions shorter sections are appropriate; e.g., steep-sided main and laterals (1 (horizontal) : 1 (vertical) or less) with a narrow bottom width of 3 feet, commonly referred to as “minimum ditches,” for outletting individual subsurface drain laterals. For conduits 10 inches in diameter and greater, longer outlet sections shall be considered, such as:

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- 10 inches and 12 inches in diameter, use 12 feet.
 - 15 inches and 18 inches in diameter, use 16 feet.
 - Use 20 feet outlet pipe for all diameters larger than 18 inches.
3. If ice or floating debris may damage the outlet pipe, the outlet shall be recessed to the extent that the cantilevered part of the pipe will be protected from the current in the ditch.
4. Headwalls used for subsurface drain outlets must be adequate in strength and design to avoid washouts and other failures.

Watertight conduits strong enough to withstand the expected loads will be used if subsurface drains cross under irrigation canals, ditches, or other structures. Conduits under roadways must be designed to withstand the expected loads. Shallow subsurface drains through depressed or low areas and near outlets must be protected from damage caused by farm machinery and other equipment and from freezing and thawing.

CONSIDERATIONS

When designing subsurface drainage systems, consider the effects the system will have on water quantity and quality.

Effects on quantity to consider include: water budget, baseflow and runoff to water uses and users, groundwater recharge, and volume of soil water needed to improve plant growth.

Water quality effects that should be considered include: delivery of sediment, changes in the delivery of dissolved salts, such as nitrates, on downstream water uses and users, changes in delivery of dissolved substances to the aquifer, downstream water temperatures, and the effects on the visual quality of downstream water.

If a concern exists of tile lines picking up polluted water from manure spreading, consider installing tile blocks, stoppable catch basins, or other temporary flow blocking devices.

Consideration should be given to using subsurface drainage to control high water tables in areas where septic tanks and leach fields exist.

Consider adding collector mains to minimize the visual impact, potential fear from ice or debris damage, and to facilitate maintenance of the grassed ditch bank.

The ability to drain and treat saline and sodic soils shall be considered where this is a problem.

Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions under federal, state, or local laws. Consideration shall be given to maintaining or enhancing environmental values.

Considerations must be given to preventing adverse impacts to delineated wetlands regulated by State and Federal regulations.

PLANS AND SPECIFICATIONS

Plans and specifications for installing subsurface drains shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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CONSTRUCTION SPECIFICATION

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INSTALLATION

Inspecting and Handling Materials

Material for subsurface drains shall be carefully inspected before the drains are installed. Plastic pipe and tubing shall be protected from hazard causing deformation or warping. Plastic pipe and tubing with physical imperfections shall not be installed. A damaged section shall be removed and a suitable joint made connecting the retained sections. Clay and concrete tile shall be checked for damage from freezing and thawing before it is installed. All material shall be satisfactory for its intended use and shall meet applicable specifications and requirements.

MATERIALS

The following specifications pertain to products currently acceptable for use as subsurface drains. These specifications are also to be applied in determining the quality of materials referenced by other standards:

Type	Specification
<u>Plastic</u>	
Corrugated polyethylene (PE) tubing and fittings 3-6 in.	ASTM-F-405
Corrugated polyethylene (PE) tubing and fittings 8-24 in.	ASTM-F-667
Corrugated polyethylene (PE) pipe and fittings 3-10 in.	AASHTO M-252
Corrugated polyethylene (PE) pipe and fittings 12 in. and greater	AASHTO M-294
Corrugated polyvinyl chloride (PVC) tubing and compatible fittings	ASTM-F-800
Polyvinyl chloride (PVC) corrugated sewer pipe with a smooth interior and fittings 4-8 in.	ASTM-F-949
Polyvinyl chloride (PVC) pipe	ASTM -D-3033 (type PSP) or ASTM-D-3034 (type PSM)
<u>Clay</u>	
Clay drain tile	ASTM-C-4
Clay drain tile, perforated	ASTM-C-498
Clay pipe, perforated, standard and extra strength	ASTM-C-700
Clay pipe, testing	ASTM-C-301
<u>Concrete</u>	
Concrete drain tile	ASTM-C-412
Concrete pipe for irrigation or drainage	ASTM-C-118
Concrete pipe or tile, determining physical properties of	ASTM-C-497
Concrete sewer, storm drain, and culvert pipe	ASTM-C-14
Reinforced concrete culvert, storm drain, and sewer pipe	ASTM-C-76
Perforated concrete pipe	ASTM-C-444
Portland cement	ASTM-C-150
<u>Other</u>	
Styrene rubber plastic drain pipe and fittings	ASTM-D-2852
Pipe, corrugated (aluminum alloy)	ASTM-B-745ec.
Pipe, corrugated (iron or steel, zinc coated)	ASTM-A-760, A-762, or A-885

ASTM Specifications can be obtained from the American Society for Testing and Materials,
1016 Race Street, Philadelphia, PA 19103

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GENERAL

The installing contractor shall certify that the installation complies with the requirements of these specifications. The contractor shall also name the source of materials.

Safety

All operations shall be carried out in a safe manner and meet applicable health and safety regulations. Workers should not enter a vertical trench deeper than 5 feet unless the trench walls are supported by shoring or by a trench shield. In lieu of shoring on trenches greater than 5 feet in depth, the walls above the 5 foot level may be sloped to a stable slope, no steeper than 1-1/2:1.

Conduit Perforations Special Requirements:

Where perforated conduit is required, the water inlet area shall be at least 1 inch²/ foot of conduit length. Round perforations shall not exceed 3/16-inch diameter except where filters, envelopes, or other protection is provided or for organic soils, where a maximum hole diameter of 1/2 inch may be used. Slotted perforations shall not exceed 1/8 inch in width.

Specifications - Flexible Conduit

I. General Requirements

All conduits shall be laid to line and grade in such a way that the sidewalls are continuously and uniformly supported with suitable bedding material. Such material shall be properly placed and compacted to provide lateral restraint against deflection and to protect the conduit against collapse during backfilling.

II. Trenching

Trench widths must be adequate for proper installation of the conduit, allow proper joining of sections, and allow proper placement of filter, envelope, or blinding materials. The trench bottom shall be constructed to proper grade before placement of the conduit.

Where rock is encountered the trench will be overexcavated a minimum of 6 inches and refilled to proper grade with a suitable bedding material.

III. Plow Installation

Special care needs to be exercised relative to grade control and bedding conditions.

IV. Bedding

The trench bottom shall be smooth and free of clods and loose or exposed rock. Where a gravel envelope is not specified, the bottom of the trench shall be shaped to conform to the pipe. The groove may be semi-circular, trapezoidal, or a 90 degree "V" shape (90 degree "V" suitable for 3-8 inches only) and shall be of such dimensions that the bottom quarter of the pipe is below the contact points of the groove.

In unstable soils a firm foundation shall be provided by over-excavation and backfilling with processed stone or gravel, suitably graded so to act as a mat into which unstable soil won't penetrate.

V. Filters and Envelopes

If a sand-gravel filter is specified, it shall be clean, hard, durable material and of the gradation specified.

When sand-gravel envelopes are used, they will be of clean, hard, durable material with less than 5 percent passing the No. 200 sieve, not more than 30 percent passing the No. 50 sieve, and with a maximum size of 1 ½ inches.

VI. Placement

Conduit will be placed in such a way that maximum stretch does not exceed 5 percent.

Fittings shall be installed in accordance with instructions furnished by the manufacturers. Couplers are required at all joints and fittings, at all changes in direction (where the centerline radius is less than three times tubing diameter), at changes in diameter, and a junction with another line.

Caps are needed at the ends of lines. All fittings shall be compatible with the tubing. Place selected bedding material, containing no hard objects larger than 1 ½ inches in diameter in the trench to a minimum depth of 6 inches over the conduit. The conduit will be held in place mechanically until secured by blinding.

VII. Backfilling

Place backfill material so that displacement or deflection of the conduit will not occur. This is preferably on an angle, so the material flows down the front slope. Avoid large stones, frozen material, and dry clods that cause concentrated point loads on the tubing. The trench should be backfilled as soon as practical. When installing the tubing on a hot day, backfilling should be delayed until tubing temperature cools to the soil temperature.

Specifications - Clay and Concrete Tile

I. Clay and Concrete Drain Tile Special Requirements

The use of concrete tile in acid and sulfate soils shall be in accordance with the following limitations:

Acid Soils:

Class of Tile	Lower Permissible Limits of pH Values	
	Organic and Sandy Soils	Medium and Heavy-Textured Soils
ASTM-C-412		
Standard quality	6.5	6.0
Extra quality	6.0	5.5
Heavy duty extra quality	6.0	5.5
Special quality	5.5	5.0
ASTM-C-14		
C-118, C-444	5.5	5.0

Note: Figures represent the lowest reading of pH values for soil or soil water at subsurface drain depth.

Sulfate Soils:

		Permissible Maximum limit of sulfates singly or in combination
Type of Tile And cement (minimum)		
Tile: ASTM-C-412		p/m
Special quality		7,000
C-14, C-118, C-444		
Cement: ASTM-C-150, Type V		
Tile: ASTM-C-412		3,000
Extra quality		
Heavy-duty extra quality		
C-14, C-118, C-444		
Cement: ASTM-C-150, Type II or V		
Tile: ASTM-C-412		1,000
Standard quality		
C-14, C-118, C-444		
Cement: ASTM-C-150, any type		

Note: Figures represent the highest reading of sulfates for soil or soil water at subsurface drain depth.

Bell and spigot, tongue and groove, and other types of tile that meet the strength, absorption, and other requirements of clay or concrete tile as specified in the preceding paragraphs, except for minor imperfections in the bell, the spigot tongue or the groove, and ordinarily classes by the industry as "seconds," may be used for drainage conduits, provided that the pipe is otherwise adequate for the job.

II. Trenching

Trenching width shall be as shown on the plans and must be adequate for proper installation of the conduit; must allow proper joining of sections; and must allow proper placement of filter, envelope, or blinding materials. The trench width will be a minimum of 3 to 6 inches on both sides of tubing. The trench bottom shall be constructed to proper grade and shape before placement of the conduit. A groove must be formed in the bottom of the trench that is adequate to hold the tile in alignment during placement and backfilling.

Where rock is encountered the trench will be overexcavated a minimum of 6 inches and refilled to proper grade with a suitable bedding material.

Provisions for safety during trenching operations shall be in compliance with the applicable safety and health regulations for construction.

III. Bedding

If unstable soil conditions are encountered, the trench bottom must be stabilized before placement of conduit. Where necessary the unstable material will be removed and replaced with sand-gravel or a similar suitable stabilizing material. Where an envelope is not specified, the bottom of the trench shall be shaped to ensure good alignment of the conduit.

Where the conduit is to be laid in a rock trench, or where rock is exposed at the bottom of the trench, the rock shall be removed below grade enough that the trench may be backfilled, compacted, and bedded; and when completed, the conduit shall be a minimum of 6 inches from rock.

IV. Filters and Envelopes

If a sand-gravel filter is specified, it shall be of clean, hard, durable material and of the gradation specified.

When sand-gravel envelopes are used they will be a clean, hard, durable material with less than 5 percent passing the No. 200 sieve, not more than 30 percent passing the No. 60 sieve, and with a maximum size of 1½ inches. ASTM-C-33 fine aggregate for concrete meets these requirements.

V. Placement

All conduits shall be laid to line and grade and covered with the specified blinding, envelope, or filter material to a depth of not less than 3 inches around the drain. Blinding material shall contain no hard objects larger than 1-½ inches in diameter.

When a sand-gravel filter is specified, all openings in the conduit must be covered with at least 3 inches of filter material except that the top of the conduit and the side filter material may be covered with a sheet of plastic or similar impervious material. The impervious sheet will be covered with at least 3 inches of blinding material.

Joints between the drain tile shall not exceed 1/8 inch, except in organic soils where some of the more fibrous types make it desirable to increase slightly the space between the tile. In sandy soils the closest possible fit must be obtained to prevent flow of soil material into the tile.

VI. Backfill

Backfill will be placed in such a manner as to avoid displacement of the conduit. Backfill should be moved into the trench at an angle so that material flows down the front slope of previously placed material. Backfill shall not contain frozen material, stones, clods, or objects large enough to damage the conduit. The trench should be backfilled as soon as possible after blinding.